610.01 General

It is the Washington State Department of Transportation's (WSDOT's) responsibility to provide for an interconnected transportation system to ensure the mobility of people and goods. In order to achieve these objectives, traffic engineers determine whether the proposed improvements will satisfy future needs by comparing the forecast directional hourly volume with the traffic-handling capacity of an improved facility. Project traffic forecasts and capacity are used to establish the number of through lanes, the length of auxiliary lanes, signal timing, right of way requirements, and other characteristics, so that the facility can operate at an acceptable level of service through the design year.

This chapter provides guidance and general requirements for traffic analyses. Specific requirements for a traffic analysis depend on a variety of factors. These include:

- Project proponents (federal, state, local, and private sector).
- Lead agency.
- Legal requirements (laws, regulations, procedures, and contractual obligations).
- Purpose of the traffic analysis.

Along with these factors, examine capacity and safety needs, look at project benefits and costs, determine development impacts, and identify mitigation requirements.

This *Design Manual* does not cover capacity analysis; see the latest version of the *Highway Capacity Manual* (HCM).

610.02 References

Laws – Federal and state laws and codes that may pertain to this chapter include:

Manual on Uniform Traffic Control Devices for Streets and Highways, USDOT, Federal Highway Administration (FHWA), National Advisory Committee on Uniform Traffic Control Devices, including the "Washington State Modifications to the MUTCD," Chapter 468-95 Washington Administrative Code (WAC), MUTCD http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

Revised Code of Washington (RCW), Chapter 43.21C, the State Environmental Policy Act (SEPA)

The National Environmental Policy Act (NEPA) of 1969

Design Guidance – Design guidance included by reference within the text includes:

Highway Capacity Manual (HCM), latest edition, Transportation Research Board, National Research Council

Roadway Delineation Practices Handbook, FHWA report, Washington, DC, 1994

Sign Fabrication Manual, M 55-05, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

"Trip Generation," Institute of Transportation Engineers (ITE)

Supporting Information – Other resources used or referenced in this chapter include:

NCHRP Synthesis 306, *Long-Term Pavement Practices*, Transportation Research Board

Development Services Manual, 3007.00, WSDOT

Traffic Manual, M51-02, WSDOT

610.03 Design Year

Roadway geometric design must consider projected traffic for the opening year and the design year. The design year for new construction and reconstruction projects is given in Chapter 440. However, the design year for developer projects is often (but not always) the horizon year or build-out year. One early task for the traffic analyst is to determine the correct design year.

610.04 Definitions

annual average daily traffic (AADT) The total volume of traffic passing a point or segment of a highway facility in both directions for one year divided by the number of days in the year.

average daily traffic (ADT) The total volume during a given time period (in whole days): greater than one day and less than one year, divided by the number of days in that time period.

capacity The maximum sustainable flow rate at which vehicles or persons can reasonably be expected to traverse a point or uniform segment of a lane or roadway during a specified time period under given roadway, geometric, traffic, environmental, and control conditions. Capacity is usually expressed as vehicles per hour (vph), passenger cars per hour (pcph), or persons per hour (pph).

capture trips Trips that do not enter or leave the traveled ways of a project's boundary within a mixed-use development.

design hourly volume (DHV) Computed by taking the annual average daily traffic times the K-factor. It can only be accurately determined in locations where there is a permanent traffic recording device active 365 days of the year. It correlates to the peak hour (see peak hour definition), but it is not equivalent. In some circumstances, it is necessary to use the peak hour data instead of DHV because peak hour can be collected using portable traffic recorders.

directional design hour volume (DDHV) The traffic volume for the design hour in the peak direction of flow, in vehicles per hour. For example, if during the design hour, 60% of the vehicles traveled eastbound and 40% traveled westbound, then the DDHV for the eastbound direction would be the DHV x 0.60.

K-factor The proportion of AADT occurring in the analysis hour is referred to as the K-factor, expressed as a decimal fraction (commonly called "K," "K30," or "K100"). The K30 is the thirtieth (K100 is the one-hundredth) highest peak hour divided by the annual average daily traffic. Normally, the K30 or K100 will be in the range of 0.09 to 0.10 for urban and rural areas. Average design hour factors are available on the web in the Transportation Data Office's Annual Peak Hour Report.

lead agency The public agency that has the principal responsibility for carrying out or approving a project.

level of service (LOS) A qualitative measure describing operational conditions within a traffic stream, based on service measures such as speed, travel time, freedom to maneuver, traffic interruptions, comfort, and convenience. Six levels of service are defined for each type of facility that has analysis procedures available. Letters designate each level, from A to F, with LOS A representing the best operating conditions and LOS F the worst. Each level of service represents a range of operating conditions and the driver's perception of those conditions. Safety is not included in the measures that establish service levels.

"pass-by" trips Pass-by trips are made as intermediate stops between an origin and a primary trip destination (for example, home to work, home to shopping).

peak hour The 60-minute interval that contains the largest volume of traffic during a given time period. If a traffic count covers consecutive days, the peak hour can be an average of the highest hour across all of the days. An A.M. peak is simply the highest hour from the A.M., and the P.M. peak is the highest from the P.M. Peak hour correlates to the DHV, but is not the same. However, it is close enough on items such as intersection plans for approval to be considered equivalent.

project Activities directly undertaken by government, financed by government, or requiring a permit or other approval from government.

"select zone" analysis A traffic model run, where the related project trips are distributed and assigned along a populated highway network. This analysis isolates the anticipated impact on the state highway network created by the project.

610.05 Travel Forecasting (Transportation Modeling)

While regional models are available in most urban areas, they may not be the best tool for reviewing developments. Most regional models are macroscopic in nature and do not do a good job of identifying intersection-level development impacts without further refinement of the model. The task of refining the model can be substantial and is not warranted in many instances. The region makes the determination whether a model or a trend line analysis can be used to take into account historical growth rates and background projects. This decision would be based on numerous factors including the type, scale, and location of the development. The regional model is generally more appropriate for larger projects that generate a substantial number of new trips. The Traffic Impact Analysis (TIA) clearly describes the methodology and process used in developing the forecast in support of the analysis of a proposed project.

610.06 Traffic Analysis

The level of service (LOS) for operating state highway facilities is based upon measures of effectiveness (MOEs), per the latest version of the *Highway Capacity Manual*.

These MOEs (see Figure 610-1) describe the measures best suited for analyzing state highway facilities, such as freeway segments, signalized intersections, on- or off-ramps, and others. Depending on the facility, WSDOT LOS thresholds are LOS C and LOS D on state highway facilities. The LOS threshold for developer projects is set differently. Refer to Chapter 4 of the *Developer Services Manual*.

(1) Trip Generation Thresholds

The following criteria are used as the starting point for determining when a TIA is needed:

- When a project changes local circulation networks that impact a state highway facility involving direct access to the state highway facility; includes a nonstandard highway geometric design feature, and others.
- The potential risk for a traffic incident is significantly increased due to congestion-related collisions, nonstandard sight distance considerations, increases in traffic conflict points, and others.
- When a project affects state highway facilities experiencing significant delay; LOS "C" in rural areas or "D" in urban areas.

Note: A traffic analysis can be as simple as providing a traffic count or as complex as a microscopic simulation. The appropriate level of analysis is determined by the specifics of a project, the prevailing highway conditions, and the forecasted traffic. For developer projects, different thresholds may be used depending on local agency codes or interagency agreements (or both) between WSDOT and local agencies. For more information, refer to Chapter 4 of the *Development Services Manual.*

TYPE OF FACILITY	MEASURE OF EFFECTIVENESS (MOE)
Basic Freeway Segments	Density (pc/mi/ln)
Ramps	Density (pc/mi/ln)
Ramp Terminals	Delay (sec/veh)
Multilane Highways	Density (pc/mi/ln)
Two-Lane Highways	Percent-Time-Spent Following Average Travel Speed (mi/hr)
Signalized Intersections	Control Delay Per Vehicle (sec/veh)
Unsignalized Intersections	Average Control Delay Per Vehicle (sec/veh)
Urban Streets	Average Travel Speed (mi/hr)

Measures of Effectiveness by Facility Type
Figure 610-1

(2) Updating an Existing Traffic Impact Analysis

A TIA may require updating when the amount or character of traffic is significantly different from an earlier analysis. Generally, a TIA requires updating every two years. A TIA might require updating sooner in rapidly developing areas and not as often in slowly developing areas. In these cases, consultation with WSDOT is strongly recommended.

610.07 Scope of Traffic Impact Analysis

Consultation between the lead agency, WSDOT, and those preparing the TIA is recommended before commencing work on the analysis to establish the appropriate scope. At a minimum, the TIA includes the following elements:

(1) Boundaries of the Traffic Impact Analysis

Boundaries are all state highway facilities impacted in accordance with the criteria in 610.06. Traffic impacts of local streets and roads can impact intersections on state highway facilities. In these cases, include an analysis of adjacent local facilities, (driveways, intersections, and interchanges), upstream and downstream of the intersection with the state highway in the TIA. A “lesser analysis” may include obtaining traffic counts, preparing signal warrants, or a focused TIA. For developer projects, the boundaries (such as the city limits) may be determined by the local agency.

(2) Traffic Analysis Scenarios

WSDOT is interested in the effects of plan updates and amendments, as well as the effects of specific project entitlements (including, but not limited to, site plans, conditional use permits, subdivisions, and rezoning) that have the potential to impact a state highway facility. The complexity and/or magnitude of the impacts of a project normally dictate the scenarios necessary to analyze the project. Consultation between the lead agency, WSDOT, and those preparing the TIA is recommended to determine the appropriate scenarios for the analysis and why they should be addressed.

(a) When only a plan amendment or update is being sought in a TIA, the following scenarios are required:

1. Existing Conditions – Current year traffic volumes and peak hour LOS analysis of affected state highway facilities.
2. Proposed Project Only With Select Zone Analysis – Trip generation, distribution, and assignment in the year the project is anticipated to complete construction.
3. Plan Build-Out Only – Trip assignment and peak hour LOS analysis. Include current land uses and other pending plan amendments/anticipated developments.
4. Plan Build-Out Plus Proposed Project – Trip assignment and peak hour LOS analysis. Include proposed project and other pending plan amendments.

(b) When a plan amendment is not proposed and a proposed project is seeking specific entitlements (such as site plans, conditional-use permits, subdivisions, rezoning, and others), the following scenarios are required to be analyzed in the TIAs:

1. Existing Conditions – Current year traffic volumes and peak hour LOS analysis of affected state highway facilities.
2. Proposed Project Only – Trip generation, distribution, and assignment in the year the project is anticipated to complete construction.
3. Cumulative Conditions (Existing Conditions Plus Other Approved and Pending Projects Without Proposed Project) – Trip assignment and peak hour LOS analysis in the year the project is anticipated to complete construction.
4. Cumulative Conditions Plus Proposed Project (Existing Conditions Plus Other Approved and Pending Projects Plus Proposed Project) – Trip assignment and peak hour LOS analysis in the year the project is anticipated to complete construction.
5. Cumulative Conditions Plus Proposed Phases (Interim Years) – Trip assignment and peak hour LOS analysis in the years the project construction phases are anticipated to be completed.

(c) In cases where the circulation element of the plan is not consistent with the land use element or the plan is outdated and not representative of current or future forecasted conditions, all scenarios from 610.07(2)(a) and (b) are to be utilized, with the exception of the duplication of (b)1 and (b)2.

610.08 Traffic Data

Prior to any fieldwork, consultation between the lead agency, WSDOT, and those preparing the TIA is recommended to reach consensus on the data and assumptions necessary for the study. The following elements are a starting point in that consideration:

(1) Trip Generation

For trip generation forecasts, use the latest edition of the Institute of Transportation Engineers' (ITE) publication, "Trip Generation." Local trip generation rates are also acceptable if appropriate validation is provided to support them.

(a) **Trip Generation Rates** – When the land use has a limited number of studies to support the trip generation rates or when the Coefficient of Determination (R2) is below 0.75, consultation between the lead agency, WSDOT, and those preparing the TIA is recommended.

(b) **Pass-by Trips** – Pass-by trips are only considered for retail-oriented development. Reductions greater than 15% require consultation and acceptance by WSDOT. Include the justification for exceeding a 15% reduction in the TIA.

(c) **Captured Trips** – Captured trip reductions greater than 5% require consultation and acceptance by WSDOT. Include the justification for exceeding a 5% reduction in the TIA.

(d) **Transportation Demand Management (TDM)** – Consultation between the lead agency and WSDOT is essential before applying trip reduction for TDM strategies. Note: Reasonable reductions to trip generation rates are considered when adjacent state highway volumes are sufficient (at least 5,000 ADT) to support reductions for the land use.

(2) Traffic Counts

Prior to field traffic counts, consultation between the lead agency, WSDOT, and those preparing the TIA is recommended to determine the level of detail (location, signal timing, travel speeds, turning movements, and so forth) required at each traffic count site. All state highway facilities within the boundaries of the TIA are to be considered. Common rules for counting vehicular traffic include, but are not limited to, the following:

(a) Conduct vehicle counts to include at least one contiguous 24-hour period on Tuesdays, Wednesdays, or Thursdays during weeks not containing a holiday and in favorable weather conditions.

(b) Conduct vehicle counts during the appropriate peak hours (see peak hour discussion below).

(c) Consider seasonal and weekend variations in traffic where appropriate (recreational routes, tourist seasons, harvest season, and others).

(3) Peak Hours

To eliminate unnecessary analysis, consultation between the lead agency, WSDOT, and those preparing the TIA is recommended during the early planning stages of a project. In general, the TIA includes a morning (A.M.) and an evening (P.M.) peak hour analysis. Other peak hours (such as 11:30 A.M. to 1:30 P.M., weekends, and holidays) might also be required to determine the significance of the traffic impacts generated by a project.

(4) Accidents

The following should be included in any discussion of the subject of accidents:

(a) A listing of the location's 3-year accident history. (For direct access points and/or intersections, the list covers an area 0.1 mile to either side of the main line or crossroad intersection).

(b) A collision diagram illustrating the 3-year accident history at each location where the number of accidents at the location has been 15 or more in the last 3 years.

(c) The predominant accident types and their locations, any accident patterns, and an assessment of and mitigation for the development's traffic safety impacts.

Also, include in the discussion the following:

1. Sight distance and any other pertinent roadway geometrics
2. Driver expectancy and accident potential (if necessary)
3. Special signing and illumination needs (if necessary)

610.09 Traffic Impact Analysis Methodologies

Typically, the traffic analysis methodologies for the facility types indicated below are used by WSDOT and will be accepted without prior consultation. When a state highway has saturated flows, the use of a microsimulation model is encouraged for the analysis (note, however, that the microsimulation model must be calibrated and validated for reliable results). Other analysis methods may be accepted; however, consultation between the lead agency, WSDOT, and those preparing the TIA is recommended to agree on the data necessary for the analysis. The methodologies include:

A. Freeway Segments – *Highway Capacity Manual (*HCM), operational analysis

B. Weaving Areas – WSDOT *Design Manual* (DM), (HCM), operational analysis

C. Ramps and Ramp Junctions – HCM, operational analysis or WSDOT DM, WSDOT Ramp Metering Guidelines (most recent edition)

D. Multilane Highways – HCM, operational analysis

E. Two-Lane Highways – HCM, operational analysis

F. Signalized Intersections – HCM, Highway Capacity Software,** operational analysis, Synchro

G. Unsignalized Intersections – HCM, (MUTCD), and WSDOT *Design Manual*, Chapter 850.05, for signal warrants if a signal is being considered

H. Transit – HCM, operational analysis

I. Pedestrians – HCM

J. Bicycles – HCM

K. WSDOT Criteria/Warrants – MUTCD (stop signs), WSDOT *Traffic Manual* (school crossings), WSDOT *Design Manual*, Chapter 840 (freeway lighting, conventional highway lighting)

L. Channelization – WSDOT *Design Manual*

M. Roundabouts – WSDOT *Design Manual*

**Note: WSDOT does not officially advocate the use of any special software. However, consistency with the HCM is advocated in most (but not all) cases. The WSDOT local development review units utilize the software mentioned above. If different software or analytical techniques are used for the TIA, then consultation between the lead agency, WSDOT, and those preparing the TIA is recommended.

Challenge results that are significantly different than those produced with the analytical techniques above. The procedures in the *Highway Capacity Manual* do not explicitly address operations of closely spaced signalized intersections. Under such conditions, several unique characteristics must be considered, including spill-back potential from the downstream intersection to the upstream intersection; effects of downstream queues on upstream saturation flow rates; and unusual platoon dispersion or compression between intersections. An example of such closely spaced operations is signalized ramp terminals at urban interchanges. Queue interactions between closely spaced intersections can seriously distort the procedures in the HCM.

610.10 Traffic Analysis Software

For applications that fall outside the limits of the HCM software, WSDOT makes use of the following software:

(1) TRANSYT-7F

TRANSYT-7F is a traffic signal timing optimization software package for traffic networks, arterial streets, or single intersections having complex or simple conditions.

TRANSYT-7F capabilities other than signal timing programs include:

- Lane-by-lane analysis
- Direct CORSIM optimization
- Multicycle and multiperiod optimization
- Detailed simulation of existing conditions
- Detailed analysis of traffic-actuated control
- Hill-climb and genetic algorithm optimization
- Optimization based on a wide variety of objective functions
- Optimization of cycle length, phasing sequence, splits, and offsets
- Explicit simulation of platoon dispersion, queue spillback, and spillover
- Full flexibility in modeling unusual lane configurations and timing plans

(2) Trafficware – Synchro

Synchro is a software application for optimizing traffic signal timing and performing capacity analyses. The software optimizes splits, offsets, and cycle lengths for individual intersections, an arterial, or a complete network. Synchro performs capacity analyses using both the Intersection Capacity Utilization (ICU) and HCM methods. Synchro provides detailed time space diagrams that can show vehicle paths or bandwidths. Synchro can be used for creating data files for SimTraffic and other third party traffic software packages. SimTraffic models signalized and unsignalized intersections, and freeway sections with cars, trucks, pedestrians, and buses.

Synchro capabilities other than signal timing programs include:

- Lane-by-lane analysis
- Direct CORSIM optimization
- Multicycle and multiperiod optimization
- Detailed simulation of existing conditions
- Detailed analysis of traffic-actuated control
- Hill-climb and genetic algorithm optimization
- Optimization based on a wide variety of objective functions
- Optimization of cycle length, phasing sequence, splits, and offsets
- Explicit simulation of platoon dispersion, queue spillback, and spillover
- Full flexibility in modeling unusual lane configurations and timing plans

(3) aaSIDRA

aaSIDRA is a software product that can analyze signalized and unsignalized intersections, including roundabouts in one package. It is a microanalytical traffic evaluation tool that employs lane-by-lane and vehicle drive cycle models.

aaSIDRA can perform signal timing optimization for actuated and pretimed (fixed-time) signals, with signal phasing schemes from the simplest to the most sophisticated.

aaSIDRA, or aaTraffic SIDRA (Signalized & unsignalized Intersection Design and Research Aid) software is for use as an aid for designing and evaluating of the following intersection types:

- Signalized intersections (fixed-time, pretimed, and actuated)
- Roundabouts
- Two-way stop sign control
- All-way stop sign control
- Yield sign control

(4) PTV America – Vissim

Vissim is a microscopic, behavior-based multi-purpose traffic simulation program, for signal systems, freeway systems, or combined signal and freeway systems having complex or simple conditions.

The program offers a wide variety of urban and highway applications, integrating public and private transportation. Even complex traffic conditions are visualized at an unprecedented level of detail providing realistic traffic models.

Vissim capabilities include:

- Dynamic Vehicle Assignment
- Land use traffic impact studies and access management studies
- Freeway and surface street interchanges
- Signal timing, coordination, and pre-emption
- Freeway weaving sections, lane adds and lane drops
- Bus stations, bus routes, carpools, and taxis
- Ramp metering and HOV lanes
- Unsignalized intersections and signal warrants
- Incident detection and management
- Queuing studies involving turn pockets and queue blockage
- Toll plazas and truck weigh stations
- Origin-destination traffic flow patterns
- Verification and validation of other software
- Surrogate for field data collection
- Public presentation and demonstration

(5) TSIS – Corsim

TSIS is a traffic simulation software package for signal systems, freeway systems, or combined signal and freeway systems having complex or simple conditions. Its strength lies in its ability to simulate traffic conditions at a level of detail beyond other simulation programs.

TSIS capabilities include:

- Land use traffic impact studies and access management studies
- Freeway and surface street interchanges
- Signal timing, coordination, and pre-emption
- Freeway weaving sections, lane adds, and lane drops
- Bus stations, bus routes, carpools, and taxis
- Ramp metering and HOV lanes
- Unsignalized intersections and signal warrants
- Incident detection and management
- Queuing studies involving turn pockets and queue blockage
- Toll plazas and truck weigh stations
- Origin-destination traffic flow patterns
- Verification and validation of other software
- Surrogate for field data collection
- Public presentation and demonstration

Use the most current version of Traffic Analysis Software. Current software licenses may be obtained from the Traffic Analysis Engineer at the HQ Traffic Office: (360) 705-7297.

610.11 Mitigation Measures

Consultation between the lead agency, WSDOT, and those preparing the TIA is recommended to reach consensus on the mitigation measures and who will be responsible. Mitigation measures must be included in the TIA, to determine if a project's impacts can be eliminated or reduced to a level of insignificance. Eliminating or reducing impacts to a level of insignificance is the standard pursuant to SEPA and NEPA. The lead agency is responsible for administering the SEPA review process and has the principal authority for approving a local development proposal or land use change. WSDOT, as a lead agency, is responsible for reviewing the TIA for impacts that pertain to state highway facilities. However, the authority vested in the lead agency under SEPA does not take precedence over other authorities in law.

If the mitigation measures require work in the state highway right of way, an encroachment permit from WSDOT is required. This work is also subject to WSDOT standards and specifications. Consultation between the lead agency, WSDOT, and those preparing the TIA early in the planning process is strongly recommended to expedite the review of local development proposals and to reduce conflicts and misunderstandings in both the local agency SEPA review process as well as the WSDOT encroachment permit process.

Additional mitigation recommendations necessary to help relieve impacts include the following:

(a) Satisfy local agency guidelines and interlocal agreements

(b) Correct any LOS deficiencies as per interlocal guidelines

(c) Donation of right of way/frontage improvements/channelization changes

(d) Installation of a traffic signal (warrant analysis per MUTCD is required)

(e) Include current/future state projects (Sunshine Report)

(f) Clear zone if widening the state highway

(g) Any proposed changes to state highway channelization require submittal of a complete channelization plan, per channelization plan checklist, for state review and approval

(h) Possible restrictions of turning movements

(i) Sight distance

(j) Traffic mitigation payment (pro-rata share contribution) to a programmed WSDOT project (see Chapter 4 of the *Development Services Manual)*

610.12 Traffic Impact Analysis Report

The minimum contents of a TIA report are listed below. The amount of text required under each element will vary depending upon the scale of the project.

I. EXECUTIVE SUMMARY

II. TABLE OF CONTENTS

A. List of Figures (Maps)

B. List of Tables

III. INTRODUCTION

A. Description of the proposed project

B. Location of the project

C. Site plan including all access to state highways (site plan, map)

D. Circulation network including all access to state highways (vicinity map)

E. Land use and zoning

F. Phasing plan including proposed dates of project (phase) completion

G. Project sponsor and contact person(s)

H. References to other traffic impact studies

IV. TRAFFIC ANALYSIS

A. Clearly stated assumptions

B. Existing and projected traffic volumes (including turning movements), facility geometry (including storage lengths), and traffic controls (including signal phasing and multisignal progression where appropriate), (figure/s)

C. Project trip generation (including references) (tables)

D. Project-generated trip distribution and assignment (figure/s)

E. LOS and warrant analyses—existing conditions, cumulative conditions, and full-build of plan conditions with and without project

V. CONCLUSIONS AND RECOMMENDATIONS

A. LOS and appropriate MOE quantities of impacted facilities with and without mitigation measures

B. Mitigation phasing plan including dates of proposed mitigation measures

C. Define responsibilities for implementing mitigation measures

D. Cost estimates for mitigation measures and financing plan

VI. APPENDICES

A. Description of traffic data and how data was collected

B. Description of methodologies and assumptions used in analyses

C. Worksheets used in analyses (for example, signal warrant, LOS, traffic count information)